Influence of Metal Salts and Graphene Oxide Incorporation on the Microstructure and Electrical Properties of Polymer Composites

Synopsis of the Ph.D. Thesis

Polymers are materials composed of macromolecules formed by the repetitive linkage of small chemical units known as monomers through covalent bonds. These large molecules exhibit a wide range of physical and chemical properties. Polymers are particularly valued for their compatibility, ease of processing, lightweight nature, frictional resistance, and diverse optical, mechanical, and electrical characteristics, making them highly attractive for various industrial applications. However, many polymers in their pristine exhibits relatively poor optical, mechanical, thermal, or electrical performance. These limitations can be overcome by tailoring their microstructure, thereby enhancing their functional properties for specific applications.

The microstructure of polymers can be tailored using various methods such as doping, polymer blending, and copolymerization. Among these, doping and polymer blending are widely regarded as effective methods for modifying the structural and functional characteristics of the host polymer, resulting in the formation of polymer or polymer blend composites [1-2]. In such systems, different metal salts/nanoparticles are incorporated into the polymeric solution to enhance their properties. When a salt is dissolved in the polymer matrix, it dissociates into free ions that are capable of migrating under an applied electric field, thereby enabling ionic conductivity similar to that observed in conventional electrolytic solutions. Solid polymer electrolytes (SPEs) can exhibit enhanced conductivity through the introduction of ionic species (referred as doping) which facilitates both ionic and electronic conduction, as well as redox reactions [3-4]. Furthermore, the incorporation of nanoparticles into the polymeric system promotes strong molecular-level interactions, leading to significant improvements in mechanical strength, thermal stability, and electrical conductivity of the resulting polymer nanocomposites.

Polymer doping involves the incorporation of inorganic salts or nanomaterials as dopants to modify the physical and chemical properties of polymers for targeted industrial applications. Unlike substitutional doping in crystalline solids, doping in polymers typically entails the introduction of dopant species between the polymer chains, where they interact with functional groups without replacing the host atoms. This process enhances the structural and functional utility of the polymer, enabling improved performance in various applications. As a result of these tailored properties, doped polymeric materials have garnered significant interest for use in solid-state polymer composites, particularly in electrochromic devices, batteries, and fuel cells [5]. When an inorganic salt or a ceramic filler is introduced into a polymer matrix, the active functional groups of the polymer interact with the dopant through various intermolecular forces such as hydrogen bonding, Coulombic attraction, dipolar interactions, and hydrophobic effects, leading to the formation of a polymer–dopant complex. Among these, hydrogen bonding has drawn particular interest due to its significant role in both inter- and intramolecular interactions between the polymer host and dopant species. These interactions play a crucial role in enhancing key properties such as ionic association and ion transport within the polymer complex. The observed increase in ionic conductivity is primarily attributed to the dissociation of inorganic salts into mobile ions. These ions migrate through the polymer matrix facilitated by the segmental motion of polymer chains and the availability of coordinating sites on or between polymer chains, thus contributing to improved ion mobility and overall conductivity. The enhancement in conductivity resulting from dopant addition is primarily associated with reduced relaxation time and increased segmental motion within the polymer matrix. These factors play a crucial role in the ion transport mechanism by facilitating greater ionic mobility in the doped polymer composites [6-7].

Nanoparticle-doped polymer composites are increasingly regarded as promising materials for energy storage device applications due to their unique structural and electrical characteristics. The incorporation of nanoparticles such as graphene oxide (GO), TiO_2, and SnO_2 into polymer matrices can significantly alter and enhance the fundamental properties of the host polymer. In typical polymer nanocomposites, the

interaction between fillers and the polymer matrix is primarily governed by weak intermolecular forces, with limited chemical bonding. However, when nanoscale dopants are used, particularly those with functional groups, they can form chemical interactions with the polymer chains. This leads to notable improvements in the structural, thermal, and electrical properties of the resulting nanocomposite. Among various nanofillers, graphene oxide (GO) stands out as an effective dopant due to its exceptional chemical reactivity, mechanical strength, thermal stability, and electrical conductivity, even at low loading concentrations [8].

Another effective approach for developing polymer/polymer blend composites with tailored properties is through the blending of different polymers, offering versatility for a wide range of applications. A polymer blend is defined as a homogeneous mixture of two or more distinct polymers, in which the structural and functional properties of the host material can be modified at the microscopic level. Polymer blends are generally classified into two categories: miscible and immiscible. Miscible blends exhibit molecular-level homogeneity and form a single-phase system, with no phase separation between the constituent polymers. For miscibility to occur, the Gibbs free energy of mixing must be lower than the sum of the Gibbs free energies of the individual components. Such blends typically exhibit a single, sharp glass transition temperature (T_g), which lies between the T_g values of the pure polymers. In contrast, immiscible blends display microscopic heterogeneity due to phase separation and are characterized by the presence of two distinct T_g values [9-10].

Aims and objectives

Based on the aforementioned surveys, it is evident that the desired properties of a polymer or a polymer blend for specific applications can be effectively achieved by incorporating various metals/fillers. The nature of property modification within the polymer matrix depends significantly on the type of dopant or the filler, its chemical characteristics, and its interaction with the host polymer. Therefore, it becomes essential to systematically investigate the influence of various dopants and fillers on the optical, microstructural, thermal, electrical, and transport properties of different polymer/polymer blends. This study specifically aims to enhance the electrical conductivity and transport properties of the host material, also improving its thermal

stability and microstructural characteristics. The primary objectives of this investigation include:

The main objectives in the present work are,

1. To Synthesize graphene oxide (GO) nanoparticles using standard method.
2. To prepare polymer/polymer blend composite films using solution casting method.
3. To analyse and understand the influence of metal salts and graphene oxide incorporation on the microstructure and electrical properties of polymer composites.
4. To understand the type of interaction of dopant/filler with the host and the effect of dopant/filler interaction with the polymer/polymer blend matrix.
5. To understand the impedance response of polymer composites for insight into ionic behaviour like relaxation behaviours of polymers chains, the charge transport properties, mobilities of charge carriers.
6. To understand the key transport parameters in detail with different dopant/additives in different host matrix: Investigate and ascertain a comprehensive set of transport parameters, such as ionic mobility and cation and anion diffusion coefficients within the polymer composites.

In the present study, polymers with distinct chemical structures and properties such as PEO, PVA, chitosan, and polyaniline have been employed as host materials, and $BaCl_2$, Li_2CO_3 salts and synthesised Graphene oxide (GO) as dopants.

Polymers: 1) Polyethylene oxide (PEO) is a semicrystalline polymer having a single helical chain structure, which facilitates ion transport within the polymer matrix. It also exhibits excellent complexation ability with a wide range of organic and inorganic salts.

2) Polyvinyl alcohol (PVA) is a semicrystalline vinyl polymer containing highly polar hydroxyl side groups, which contribute to its strong hydrogen bonding capability. Its structure enables the formation of stable complexes with a variety of dopants, making it a suitable candidate for composite and functional material applications.

3) Chitosan (CS) is a semicrystalline polymer derived from chitin and consists of a linear chain of polyaminosaccharides. Its ability to undergo enzymatic hydrolysis

makes it biodegradable, which has led to its widespread use in various technological and environmental applications.

4) Polyaniline (PANI) is one of the most extensively studied conducting polymers, known for its tunable electrical conductivity and environmental stability. It has promising applications in lightweight organic batteries and other energy storage devices. Literature reports indicate that the incorporation of carbon-based nanomaterials into PANI significantly enhances the structural, electrical, and electrochemical properties of the resulting composite materials.

Dopants/fillers: 1) Barium chloride ($BaCl_2$) - inorganic compound with large Ba^{2+} ions (divalent) may provide additional sites for ion migration within the composite.

2) Lithium carbonate (Li_2CO_3) - monovalent inorganic salt composed of lithium cations (Li^+) and carbonate anions (CO_3^{2-}) exhibiting less lattice energy compared to $BaCl_2$ salt. It is widely used in electrochemical applications due to its high ionic conductivity and ability to release lithium ions, making it a suitable dopant for enhancing the performance of polymer electrolytes and other energy storage materials.

3) Synthesized Graphene oxide (GO) is rich in oxygen-containing functional groups, including carboxyl, hydroxyl, and epoxide groups. These functionalities impart unique characteristics to GO, such as hygroscopicity, excellent dispersibility in polar solvents, and the ability to intercalate between the polar segments of polymer chains. The presence of epoxy groups further facilitates strong interactions with polymer matrices, making GO a highly suitable nanofiller for enhancing the structural and functional properties of polymer composites.

The influence of doping on the structural, optical, thermal, and electrical properties of polymer and polymer blend systems has been extensively investigated using a range of analytical techniques. These include Fourier Transform Infrared (FTIR) spectroscopy, Ultraviolet–Visible (UV-Vis) spectroscopy, X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Thermogravimetric Analysis (TGA), AC conductivity measurements, impedance spectroscopy, and evaluations of transport and diffusion coefficients. The comprehensive results of these investigations are systematically presented into **seven chapters** of this thesis.

Chapter I provides a broad overview, and outlines the motivation behind the present study. It begins with a brief **Introduction** to polymers and the role of doping in modifying their properties. The chapter further discusses the significance of material characterization, along with the motivation, aims, and objectives of the research. It also introduces the fundamental principles of the techniques employed to investigate the changes in structural, thermal, electrical, and transport properties of doped polymer and polymer blend systems. Additionally, a comprehensive literature review is presented, covering the synthesis and characterization of polymer/polymer blend electrolytes, with a focus on their microstructural, thermal, electrical, and ion transport behaviours.

Chapter II presents a detailed account of the **Experimental Methods and Characterization Techniques** employed to investigate the pure and doped polymer/polymer blend electrolyte systems. The synthesis of nanoparticles using the modified Hummers' method, as well as the preparation of pure and doped polymer/polymer blend films via the solution casting technique, are thoroughly described. This chapter also outlines the various experimental techniques used for characterization, including UV–Visible spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Thermogravimetric Analysis (TGA), impedance spectroscopy, AC conductivity measurements, and the evaluation of transport properties.

Chapter III focuses on the **impact of $BaCl_2$ doping on the microstructural, electrical, and transport properties of PEO-based solid polymer electrolyte films**. In this chapter, polyethylene oxide (PEO) is employed as the host polymer, with barium chloride ($BaCl_2$) used as the dopant. FTIR spectral analysis reveals that $BaCl_2$ interacts with the PEO matrix, leading to the formation of a polymer-dopant complex. UV-Visible spectroscopy further confirms the presence of this complex, indicating that doping alters the optical properties of PEO. Based on the UV-Vis absorption data, the optical energy band gap and Urbach energy were calculated for various doping concentrations. The observed variations in these parameters demonstrate that the optical properties of PEO are significantly influenced by the level of $BaCl_2$ doping. X-ray diffraction (XRD) analysis indicates that $BaCl_2$ doping alters the microstructure of the

PEO polymer, leading to an increase in its amorphous nature. This enhancement in amorphousness is further supported by SEM micrographs, which show smooth and homogeneous surfaces without any signs of phase segregation or interfacial layering at higher salt concentrations. Thermogravimetric analysis (TGA) reveals that $BaCl_2$ doping modifies the thermal properties of the polymer composite, demonstrating the doping improves the thermal property of the PEO matrix. AC conductivity analysis reveals that the ionic conductivity of the electrolyte film increases with both dopant concentration and frequency, with the highest conductivity observed at 10 wt% $BaCl_2$. The temperature-dependent conductivity study shows a consistent increase in conductivity with rising temperature, and the observed trend follows Jonscher's universal power law. Cole-Cole plots further illustrate that the resistive component decreases and the relaxation time reduces with increasing salt concentration and temperature, indicating enhanced ion transport dynamics within the doped polymer matrix. The transport property study reveals that the ion transference number is greater than the electronic transference number, indicating ions (H^+) serve as the dominant charge carriers, while the contribution from electronic conduction is negligible.

Chapter IV presents the **investigation of microstructural and electrical properties of Li^+ ion-conducting polymer blend electrolytes.** In this study, a polymer blend of polyvinyl alcohol (PVA) and chitosan (CS) is used as the host matrix, with lithium carbonate (Li_2CO_3) serving as the dopant. FTIR analysis confirms the interaction of Li^+ ions with the hydroxyl and amine functional groups of the polymer blend, indicating the formation of complexes. Optical characterization through UV-Visible spectroscopy is used to estimate the optical energy band gap and Urbach energy. The observed variations in these parameters reflect significant modifications in the optical properties of the polymer blend upon doping. XRD analysis confirms structural modifications in the polymer blend induced upon Li-salt doping, indicating changes in the degree of crystallinity. The modification in the surface morphology upon doping is revealed by FESEM analysis. Thermogravimetric analysis (TGA) demonstrates enhanced thermal stability of the electrolyte films upon doping. Impedance spectroscopy indicates that the formation of ion-polymer complexes in the doped blend significantly influences ionic

mobility, thereby affecting the overall ionic conductivity. The observed changes in conductivity are attributed to the hopping mechanism of charge carriers within the polymer matrix. Consistent with earlier findings, the results confirm that ionic species are the predominant charge carriers, with negligible electronic contribution to the conductivity.

Chapter V describes the **microstructural, electrical, and transport properties of graphene oxide (GO)-reinforced PVA-CS polymer blend nanocomposites.** In this study, GO is synthesized using the modified Hummers' method and incorporated into the PVA-CS polymer matrix. FTIR analysis is employed to investigate the chemical modifications in both the pristine and GO-doped polymer blend nanocomposite films. The results indicate that GO interacts effectively with the PVA-CS matrix, leading to notable structural modifications within the blend. UV-Visible absorption spectroscopy reveals that the formation of complexes due to GO doping alters the optical properties of the polymer blend, including a reduction in optical band gap energy and changes in Urbach energy. XRD analysis confirms structural modifications in the blend, which are further supported by FESEM images showing corresponding changes in surface morphology. TGA results indicate enhanced thermal stability of the blend upon GO incorporation. Impedance spectroscopy demonstrates that doping significantly influences charge carrier mobility, relaxation dynamics, and overall conductivity. Furthermore, the temperature-dependent conductivity of the doped polymer blend follows Jonscher's Universal Power Law, indicating an increase in conductivity with temperature. Transport property revealed the H^+ ions are the majority charge carriers in the polymer blend nanocomposites.

Chapter VI focuses on the **synthesis, characterization, and conductivity studies of polyvinyl alcohol/polyaniline/graphene oxide (PVA-PANI-GO) polymer nanocomposites.** Both pristine and GO-doped PVA-PANI polymer nanocomposites are synthesized and systematically characterized using various analytical techniques. FTIR spectroscopy confirms the interaction between GO and the PVA-PANI polymer chains, leading to the formation of charge transfer complexes within the doped composites. UV-Visible spectroscopy, along with the analysis of optical band gap and

Urbach energy, indicates that these complexes significantly influence the optical properties of the polymer blend films. XRD analysis reveals an increase in the crystallinity of the polymer blend upon GO doping, attributed to the formation of charge transfer complexes within the matrix. These structural modifications also influence the surface morphology of the composite films, as observed in SEM micrographs. TGA results demonstrate improved thermal stability of the doped composites. Additionally, the variation in electrical properties, such as dielectric parameters, ionic conductivity, and ion transport behaviour with different filler concentration is studied and analysed.

Chapter VII presents the overall summary of the present work and outlines the scope for future research. The findings from this investigation clearly demonstrate that polymer properties can be effectively tailored through dopant incorporation or polymer blending. The study specifically examines the effect of different dopants and a filler namely, metal salts ($BaCl_2$ and Li_2CO_3) and a nanoparticle (graphene oxide) on the microstructural, thermal, electrical, and transport properties of polymer/polymer blend matrix. Results reveal that these dopants/fillers induce significant modifications in the optical, thermal, electrical, and transport characteristics of the host material.

The outcomes of these investigations have been published in peer-reviewed journals and presented at various national and international conferences and symposia. Publication details are given in the form of list of publications.

References

1) M.F. Shukur, R. Ithnin, H.A. Illias, M.F.Z. Kadir, Optical Materials 25 (2013) 1834-1841.
2) Sunil G. Rathod, R. F. Bhajantri, V. Ravindrachary, T. Sheela, P. K. Pujari, Jagadish Naik, Boja Poojary, J Polym Res 22:6, (2015) 1-14.

3) Atif Islama, Zahid Imran, Tariq Yasin, Nafisa Gull, Shahzad Maqsood Khan, Muhammad Shafiq, Aneela Sabir, Muhammad Azeem Munawar, Muhammad Hamid Raza, Tahir Jamil, Materials Research 18(6), (2015) 1256-1263.
4) R. F. Bhajantri, V. Ravindrachary, A. Harisha, Vincent Crasta, Suresh P. Nayak, Boja Poojary, Polymer 47 (2006) 3591 3598.
5) A. Bac, M. Ciosek, M. Bukat, M. Marczewski, H. Marczewska, W. Wieczorek, Journal of Power Sources 159, (2006) 405-411.
6) Hua Zheng, Yumin Du, Jiahui Yu, Ronghua Huang, Lina Zhang, Journal of Applied Polymer Science 80, (2001) 2558–2565.
7) A.L. Saroj, R.K. Singh, Journal of Physics and Chemistry of Solids 73, (2012) 162–168.
8) Shujahadeen B. Aziz, Ranjdar M. Abdullah, Mariwan A. Rasheed, Hameed M. Ahmed, Polymers 9, (2017) 338.
9) R.F. Bhajantri, V. Ravindrachary, Boja Poojary, Ismayil, A. Harisha, Vincent Crasta, Polymer Engineering and Science 49(5), (2009) 903-909.
10) Andreea Madalina Pandele, Mariana Ionita, Livia Crica, Sorina Dinescu, Marieta Costache, Horia Iovu, Carbohydrate Polymers 102, (2014) 813– 820.

List of Publications

i) Journals

1. Microstructure and electrical properties of Li^+ - ion conducting polymer blend electrolyte films.

Rohan N Sagar, Ravindrachary V, Shreedatta Hegde. Express Polymer Letters 17: 883–899 (2023). IF: 2.7

2. Microstructure, electrical, and transport properties: Graphene oxide reinforced poly (vinyl alcohol)- chitosan based polymer blend electrolytes.
   Rohan N. Sagar, V. Ravindrachary, Shreedatta Hegde Materials Science and Engineering: B 317 118137 (2025). IF: 4.6
3. Effect of BaCl2 doping on structural and electrical properties of PEO based solid polymer electrolyte films.
   Rohan N. Sagar, V. Ravindrachary, Guruswamy B, Shreedatta Hegde and Praveena S.D. Res. J. Physical Sci. Vol. 5(2), (2017)5-7.
4. Effect of TiO2 nanoparticles doping on structural and electrical properties of PVA: NaBr polymer electrolyte.
   Rohan N Sagar, V. Ravindrachary, B Guruswamy, Shreedatta Hegde, B K Mahanthesha, R Padma Kumari AIP Conf. Proc. 1953, (2018) 030216-1–030216-4
5. Transport and Diffusion Properties in PEO-BaCl2 Polymer Electrolytes for Battery Applications.
   Rohan N Sagar, V. Ravindrachary, Shreedatta Hegde, B Guruswamy, Journal of Physics: Conference Series, 1172 (2019) 012078 88 89
6. Microstructural, dielectric, and transport properties of proton-conducting solid polymer electrolyte for battery applications.
   Shreedatta Hegde, V Ravindrachary, S. D Praveena, B Guruswamy, **Rohan N Sagar**, Ionics 26:2379–2394 (2019) 1-16. Impact factor 2.817
7. Relaxation and transport properties of Li+ ion conducting biocompatible material for battery application.
   Shreedatta Hegde, V Ravindrachary, SD Praveena, B Guruswamy, **Rohan N Sagar**, Ganesh Sanjeev AIP Conf. Proc., 1942, (2018) 10043-1–10043-4.
8. Optical and Dielectric Properties of Li+ Ion Conducting Solid Polymer Electrolyte. Shreedatta Hegde, V Ravindrachary, B Guruswamy, C Shruthi, **Rohan N Sagar**, Indian Journal of Advances in Chemical Science, 2018; 6(2) 83-87.

9. Microstructural, Electrical and Thermal properties of Lithium ion conducting solid polymer electrolyte.

   Shreedatta Hegde, V. Ravindrachary, S. D. Praveena, B. Guruswamy, **Rohan N Sagar**, C Shruthi., International Journal of Latest Trends in Engineering and Technology. E- ISSN:2278-621X, (2017) p-ISSN: 2319-3778.

10. Optical, thermal and morphological study of ZnS doped PVA polymer nano composites.

    B Guruswamy, V Ravindrachary, C Shruthi, **Rohan N Sagar**, Shreedatta Hegde, AIP Conf. Proc. 1953, (2018) 030211-1– 030211-4. 90

11. Diffusion, swelling, cross linkage study and mechanical properties of ZnO doped PVA/NaAlg blend polymer nanocomposite.

    B Guruswamy, V Ravindrachary, C Shruthi, Shreedatta Hegde, **Rohan N Sagar**, AIP Conf. Proc. 1942, (2018) 040022-1–040022-4.

12. Inhibition and quenching effect on positronium formation in metal salt doped polymer blend.

    S D Praveena, V Ravindrachary, Ismayil, RF Bhajantri, A Harisha, B Guruswamy, Shreedatta Hegde, **Rohan N Sagar**, AIP Conf. Proc. 1942, (2018) 080004-1–080004-4.

13. Optical, Electrical and Thermal Properties of SnO2 Nanoparticles doped Poly Vinyl Alcohol-Poly Vinyl Pyrrolidone Blend Polymer Electrolyte.

    B Guruswamy, V. Ravindrachary, C. Shruthi, Shreedatta Hegde, **Rohan N. Sagar**, S. D. Praveen. Indian Journal of Advances in Chemical Science, 2018; 6(1): 17-20.

14. Effect of lithium bromide doping on structural, dielectric, and transport properties of methylcellulose-based solid polymer electrolyte films.

    Shreedatta Hegde, V Ravindrachary, Ismayil, B Guruswamy, **Rohan N Sagar**, G Sanjeev Indian Journal of Physics, 2024 98 (1), 139-155

15. Effect of electron irradiation on optical, thermal and electrical properties of LiClO4/PVA polymer composite.

BK Mahantesha, V Ravindrachary, R Padmakumari, R Sahanakumari, **Rohan N Sagar**, Pratheeka Tegginamata, Ganesh Sanjeev, AS Mishra AIP Conference Proceedings, 2020 2244 (1)

ii) International/National-Conferences/Symposium

1. Effect of BaCl2 doping on Structural and electrical properties of PEO based Solid Polymer electrolyte films.

   Rohan N Sagar, V Ravindrachary, Guruswamy B, Shreedatta Hegde, and Praveena S D. 6Th ISC-2016, Hutatma Rajguru Mahavidylaya, Pune, Maharastra, India- on Dec-08 to 09 2016. ISBN978-93-84659-14-1.

2. Structural, Electrical and Ion Transport properties of GO doped PVA/CH blend polymer composite.

   Rohan N Sagar, V Ravindrachary, Guruswamy B, Shreedatta Hegde, Shruthi C 9th to 11th August 2017, ICONN 2017 SRM University Chennai.

3. Effect of TiO2 Nanoparticles Doping on Structural and Electrical Properties of PVA:NaBr Polymer Electrolyte.

   Rohan N Sagar, V. Ravindrachary, Guruswamy. B, Shreedatta Hegde, Mahanthesh B. K, Padmakumari R ICC-2017 held At 24 to 25th Nov 2017, Govt, Eng College, Bikaner Rajasthan.

4. Transport and Diffusion Properties in PEO-BaCl2 Polymer Electrolytes for Battery Applications.

   Rohan N Sagar, V. Ravindrachary, Shreedatta Hegde, Guruswamy B ICAPPM-2018", held at Swami Vivekananda Institute of Technology (SVIT), Secunderabad, India during 5th and 6th December 2018

5. Optical, Electrical and Relaxation Studies: Functionalized Graphene based PVA- CS Blend Composites for Energy Storage Device Applications.

   Rohan N Sagar, Ravindrachary V, Shreedatta Hegde, Guruswamy B. 11th International Exergy, Energy and Environment Symposium IEEES'1 – 2019 held at SRM Institute of Science and Technology, INDIA during July 14th – 18th 2019.

6. Optical, Thermal and Microstructure Studies on Cadmium Oxide Nano Particles Doped Sodium Alginate.

   B Guruswamy, V Ravindrachary, R F Bhajantri , S D Praveena, Shreedatta Hegde, C Shruthia, **Rohan N Sagar** FUNHE-2016, Mangalore University. 91

7. Effect of NaBr doping on Microstructural and Electrical properties of Polyethylene oxide.

   Shreedatta Hegde, V Ravindrachary, Praveena S D, Guruswamy B, **Rohan N Sagar**, and Shruthi C SCICON'16 Amirita University, Tamil Nadu, Coimbatore-2016 Dec 19th-20th, ISBN 978-93-86176-47-9.

8. Dielectric and Microstructural Properties of Polymer Blend Composite.

   S D Praveena, V Ravindrachary, A Harisha, Ismayil, R F Bhajantri, B Guruswamy, Shreedatta Hegde, **Rohan N Sagar**, SCICON'16 Amirita University, Tamil Nadu, Coimbatore-2016 Dec 19th-20th, ISBN 978-93-86176-47-9

9. Optical, Thermal, Electrical and Nano structural Study of PVA-PVP doped with SnO2 Nanoparticles.

   B Guruswamy, V Ravindrachary, R F Bhajantri S D Praveena, Shreedatta Hegde, **Rohan N Sagar**, CMPA-2016, MIT Manipal 23-24 May 2016.

10. Optical, Structural and Thermal properties of NH4Cl/PVA polymer composites.

    Shreedatta Hegde, V Ravindrachary S D Praveena B Guruswamy, **Rohan N Sagar**, C Shruthi CMPA-2016, MIT Manipal 23-24 May 2016

11. Optical, thermal and morphological study of PVA-NaAlg/ZnO Nanocomposites.

    B Guruswamy, V Ravindrachary, S D Praveena, Shreedatta Hegde, C Shruthi, **Rohan N Sagar**, ICNAN- 2016, VIT University, Tamil Nadu, Vellore, 19-21 Oct 2016. ISBN:978-93-86256-06-5.

12. Dielectric, thermal and morphological study of PVA doped with CuO Nanocomposite.

    B Guruswamy, V Ravindrachary, S D Praveena, Shreedatta Hegde, C Shruthi, **Rohan N Sagar**, APST-2016, VIT University, Tamil Nadu, Vellore, 24-26 Oct 2016.

13. Microstructural, Electrical and Thermal properties of lithium ion conducting solid Polymer Electrolyte.

    Shreedatta Hegde, V Ravindrachary, S D Praveena, B Guruswamy, **Rohan N Sagar**, C Shruthi International conference on Nanotechnology: The Fruition Of Science (ICON-17) 15th & 16th February, 2017, Nesamony Memorial Christian college, Marthandam, TN.

14. Effect of Methyl Violet doping on Microstructural, Optical and thermal properties of Poly vinyl alcohol (PVA).

    Padmakumari R, Ravindrachary V, Mahantesha B K, **Rohan N Sagar**, Shreedatta Hegde, Guruswamy B, Shruthi C and Sahanakumari R. National conference on particle accelerators in Interdisciplinary research (PAIR) Mangalore University. April 11-13, 2017. 92

15. Effect of Electron irradiation on Optical and surface morphological properties of Li2CO3 doped PVA polymer electrolyte.

    Mahanthesh BK, Ravindrachary V, Padmakumari R, **Rohan N Sagar**, Guruswamy B, Shreedatta Hegde, Sahana Kumari R, V C Petwal, Jishnu Dwivedi, 9th to 11th August 2017, ICONN 2017 SRM University Chennai.

16. Optical, Electrical And thermal Properties of CuO doped PVA Nanocomposite. B Guruswamy, V Ravindrachary, C Shruthi, Shreedatta Hegde, **Rohan N Sagar**, ICAMMM2017, Govt Engg College, Salem, Tamilu Nadu, March 6th to 8th 2017.

17. Optical, Electrical and Thermal Properties of SnO2 Nanoparticles doped PVA-PVP blend polymer Electrolyte.

    Guruswamy B, V Ravindrachary, Shruthi C, Shreedatta Hegde, **Rohan N Sagar**, POLYOCON - 2017 15th and 16 Sep 2017 SJCE Mysore.

18. Optical and Dielectric Properties of Li+ Ion Conducting Solid Polymer Electrolyte, Shreedatta Hegde, V Ravindrachary, B Guruswamy, C Shruthi, **Rohan N Sagar**, POLYOCON2017,15th and 16 Sep 2017 SJCE Mysore.

19. Effect of L-Arginine doping on Microstructural and Optical properties of PVA Polymer.

Mahantesha B K, Ravindrachary V, Padmakumari R, **Rohan N Sagar**, Guruswamy B, Shreedatta Hegde, Shruthi C and Sahanakumari R National Conference on Recent Trends in Physics, 26th Sep 2017, Bharathi College Mandya.

20. Optical, Thermal and Morphological Study of Zns Doped PVA Polymer Nanocomposites.

B Guruswamy, V Ravindrachary, C Shruthi, **Rohan N Sagar**, Shreedatta Hegde ICC-2017 held 24 to 25th Nov 2017, Govt, Eng College, Bikaner Rajasthan.

21. Diffusion, swelling, cross linkage study and mechanical properties of ZnO doped PVA/NaAlg blend polymer nanocomposites.

B. Guruswamy, V. Ravindrachary, C. Shruthi, Shreedatta Hegde, **Rohan N. Sagar**, DAE Solid State Physics Symposium 2017, BARC Mumbai Dec 25th to 30th 2017 93

22. Effect of KBr doping on Electrical and optical properties of polyvinyl alcohol (PVA).

Mahantesha B K, Ravindrachary V, Padmakumari R, **Rohan N Sagar**, Guruswamy B, Shreedatta Hegde, Shruthi C and Sahana Kumari R. National conference on particle accelerators ininterdisciplinary research (PAIR) Mangalore University. April 11-13, 2017.

23. Inhibition and quenching effect on positronium formation in metal salt doped polymer blend.

S. D. Praveena, V. Ravindrachary, Ismayil, R. F. Bhajantri, A. Harisha, B. Guruswamy, Shreedatta Hegde, **Rohan N. Sagar**, DAE Solid State Physics Symposium 2017. BARC Mumbai Dec 25th to 30th 2017.

24. Relaxation and Transport Properties of Li+ Ion Conducting Biocompatible Material for Battery Application.

Shreedatta Hegde, V Ravindrachary, S D Praveena, B Guruswamy, **Rohan N Sagar**, Ganesh Sanjeev. DAE Solid State Physics Symposium 2017. BARC Mumbai Dec 25th to 30th 2017

25. Microstructural and Dielectric Studies of Lithium ion conducting Solid Biopolymer Electrolytes for Energy Storage Application.

Shreedatta Hegde, V. Ravindrachary, C. Shruthi, B. Guruswamy, **Rohan N. Sagar**, UGC Sponsored Two Day National Conference On "Synthetic, Spectroscopic and Structural Chemistry, Held at Govinda Dasa College, Surathkal, Karnataka, during 15th to 16th March 2019.

26. Dielectric Relaxation and Transport Properties of Lithium ion conducting Solid Biopolymer Electrolytes for Energy Storage Application.

Shreedatta Hegde, V Ravindrachary, Ismayil, S. D. Praveena, B Guruswamy, **Rohan N Sagar**, 11th International Exergy, Energy and Environment Symposium IEEES'11–2019 held at SRM Institute of Science and Technology, INDIA during July 14th – 18th 2019.

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Research Guide